Wykład CXIX JCET, 31.01.2020 r.

Raman, SERS and SRS Spectroscopy for Bioanalysis

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Raman, SERS and stimulated Raman scattering (SRS) are techniques that can be used to provide a rich amount of information on a number of different biological systems. This presentation will cover the use of Raman, SERS and SRS spectroscopy to understand more about the biological nature of cancer and in particular lipid changes in response to drug treatments. Data will be presented on the use of Raman spectroscopy to understand more about the effect of small molecule drugs on cancer cells relative to non-cancer cells and in particular on the lipid synthesis. To achieve this, we have used 2D mapping in the high wavenumber region and ratiometric analysis used to understand the effect of small molecule drugs on the increase or decrease on lipid synthesis on prostate cancer cells (Figure 1). The results have shown some interesting selectivity for a particular small molecule relative to a normal cell in that this small molecule has a

preference for a cancer cell and appears to up regulate the lipids. This was a very simple approach to understanding the effect of small molecule drugs and the data presented will show how Raman spectroscopy and ratiometric analysis can be used to provide an accurate analysis on the effects of small molecule drugs on cancer cells and whether further in depth testing of the efficacy of these drugs as anti-cancer agents should be pursued.[1] A second area of investigation involves using tumour sections and analysis of the lipid changes to understand more about the mechanisms of resistance to treatment regimes. These two examples show how Raman spectroscopy can be used to probe biology and provide useful data to inform future experiments and thinking.

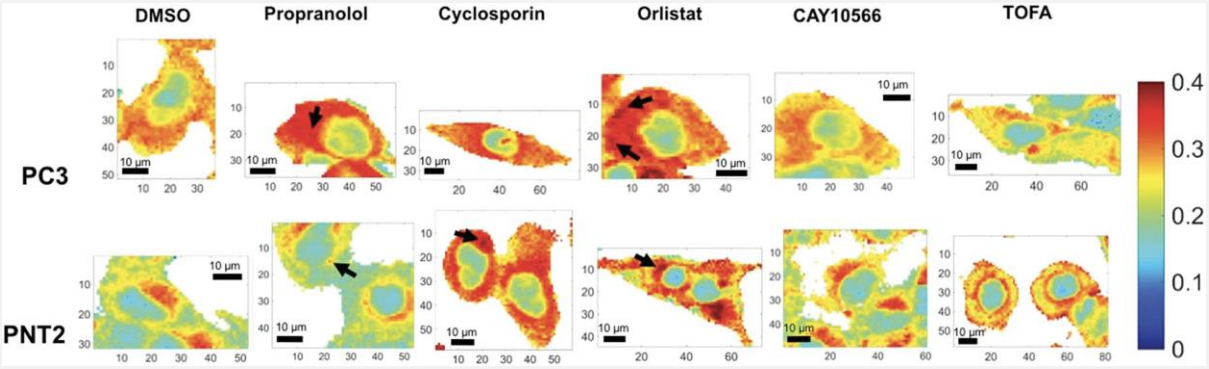

Figure 1. Ratiometric Raman imaging of intracellular lipid distribution. Representative examples of fixed cell regions mapped using a Raman microscope for two prostate cancer cell lines, PC3 and PNT2, treated with DMSO (control), or a lipid altering drug. After processing in Wire 4.1 and MATLAB®, false color images of the ratio of peak intensity at 2851 cm^{-1} and the sum of the peak intensities at 2933 cm^{-1} and 2851 cm^{-1} were created as a reflection of lipid/(protein + lipid) ratio. White areas represent background regions of the map that were omitted after selecting cellular regions. Cells were mapped using 532 nm, 0.5 s acquisition, 15 mW laser power, 1 cm step size in x and y and a spectral center of 3000 cm^{-1}. Example regions of high intensity, potentially corresponding to lipid droplets, are indicted using arrows. Spatial coordinates on images are in cm.[1]

[1] Jamieson, L., Wetherill, C., Faulds, K., Graham, D. *Chemical Science*, **2018**, 9, 6935-6943.

SHORT BIOGRAPHY

Prof. Duncan Graham

POSTS HELD:

2019	Distinguished Professor, Pure and Applied Chemistry
2016-	Head of Department, Pure and Applied Chemistry
2010-2012	Director, WestCHEM
2008-	Head of Research Pure and Applied Chemistry, University of Strathclyde
2008- 2010	Deputy Director, WestCHEM
2004	Professor, Pure and Applied Chemistry, University of Strathclyde
2002-2004	Lecturer, then Senior Lecturer, Pure and Applied Chemistry, University of Strathclyde
1997-2002	BBSRC David Phillips Five-Year Fellow, University of Strathclyde
1996-1997	Postdoctoral researcher, University of Strathclyde with Prof Ewen Smith.

AWARDS & FELLOWSHIPS

Charles Mann Award for Applied Raman Spectroscopy, FACSS, 2017
Theophilus Redwood Award, Royal Society of Chemistry, 2016
Japan Society for Promotion of Science Fellowship, 2015
Fellows award from the Society for Applied Spectroscopy, 2012
Craver award of the Coblentz Society, 2012
Royal Society Wolfson Research Merit Award, 2010
Corday Morgan Prize of the Royal Society of Chemistry, 2009
Fellowship of the Royal Society of Edinburgh, 2007
Nexxus Young Life Scientist of the Year, 2005
RSC's SAC Silver Medal, 2004.
RSC's Analytical Grand Prix Five Year Fellowship, 2002.

QUALIFICATIONS:

1996 PhD, Department of Chemistry, University of Edinburgh
1992 BSc (Hons) Chemistry, University of Edinburgh

ADDITIONAL FACTORS:

- Editor in Chief of Analyst, previously scientific editor for reviews, board member since 2006.
- Member of international advisory boards for Chemical Science, Chemical Society Reviews, Analytical Methods, Journal of Raman Spectroscopy and Bioimaging Spectroscopy and Imaging.
- Invited guest editor for special editions of *Chem. Soc. Rev. x 2*, *Chem. Commun. x 2*, *J. Biophoton.*, *Analyst x2*.
- Chair of EPSRC roadmap for Raman and IR capability in the UK, 2015/16.
- Chair of panel for EPSRC response to the review of Analytical Sciences in the UK, 2015.
- Chair of Faraday Discussion on SERS (2017), Chair of GRC on Bioanalytical Sensors (2018).
- Co-chair Raman Program, SciX, RSC representative for FACSS.
- President of the Analytical Division of the Royal Society of Chemistry, Chair Analytical Chemistry Trust Fund

PUBLICATIONS: 231 papers, 7 book chapters, 10 editorials, 45 peer reviewed proceedings and 16 patents

H-INDEX: 58 with ~12500 citations. (41 from 2014 with over 6500 citations in that period, Google).

INVITED LECTURES: >200 with >100 international.

CURRENT FUNDING: PI = 3.2 M, CI = 9 M.

5 KEY PUBLICATIONS:

(1.) In vivo multiplex molecular imaging of vascular inflammation using surface-enhanced Raman spectroscopy, Noonan, J., Asiala, S., Grassia, G., MacRitchie, N., Gracie, K., Carson, J., Moores, M., Girolami, M., Bradshaw, A., Guzik, T.J., Meehan, G. R., Scales, H., Brewer, J.M., McInnes, I.B., Sattar, N., Faulds, K., l Garside, P., **Graham, D.***, Maffia, P.* **Theranostics**, **2018**, 8, 22, 6195-6209.

(2.) Ratiometric Raman imaging reveals the new anti-cancer potential of lipid targeting drugs, Jamieson, L., Wetherill, C., Faulds, K., **Graham, D.***, **Chemical Science**, **2018**, 9, 6935-6943.

(3) Imprinting of Chiral Signatures on an Achiral Nanoprobe: A Novel Chiroptical Phenomenon Measured by Surface Enhanced Resonance Raman Optical Activity, Ostovar Pour, S., Rocks, L., Faulds, K., **Graham, D.**, Parchansky, V., Bour, P., Blanch E.W.* ***Nature Chemistry***, **2015**, 7, 591–596.

(4) Extreme Red Shifted SERS Nanotags, Bedics, M.A. Kearns, H., Cox, J.M., Mabbott, S., Ali, F., Shand, N.C., Faulds, K., Benedict, J.B., **Graham, D.***, Detty, M.R.* ***Chemical Science***, **2015**, 6, 2302 - 2306.

(5) Control of Enhanced Raman Scattering Using a DNA Based Assembly Process of Dye Coded Nanoparticles, **Graham, D.**,* Thompson, D., Faulds, K., Smith, W.E., ***Nature Nanotechnology***, **2008**, 3, 9, 548-551.